An examination of drivers and barriers to reducing carbon emissions in China's manufacturing sector

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An Examination of Drivers and Barriers to Reducing Carbon Emissions in China's Manufacturing Sector

Abstract

Purpose: Carbon Efficient Practices (CEPs) are gaining momentum due to the serious consequences of climate change. While past studies have focused on the effects of either drivers or barriers to green practices especially in the context of developed countries, relatively little attention has been devoted to the simultaneous effects of drivers and barriers on product redesign, particularly in the context of China.

Design/methodology/approach: Using a blend of the Contextual Interaction Theory and Newton's 2nd Law of Motion, this paper proposes a conceptual model that simultaneously examines the impact of CEP drivers and barriers on product redesign and performance.

Finding: Structural Equation Modelling (SEM) analysis on a sample of 239 Chinese manufacturing firms indicated that drivers had substantially higher effects on product redesign and performance compared to the influence of other barriers.

Originality/value: Use of Newton's 2nd Law of Motion as a theoretical framework for understanding the adoption of CEPs in the context of China is novel. Implications of this pattern of results on academic theory building and practice are offered.

Keywords: Reverse Logistics, Drivers, Barriers, Performance, Manufacturing, China

Article Type: Research paper

1. Introduction

Climate change is a serious threat to humanity given its increasing negative effect in terms of ozone layer depletion, air and water pollution, and depletion of non-renewable natural resources upon which life generally depends. One of the major contributors to climate change, for example, are greenhouse gas emissions and these are generally measured in terms of carbon footprints. Different societal activities emit varying amount of carbon footprints and among them industrial and logistics operations contributions are predominant. These business operations emit wastes, unprocessed effluents, consume exorbitant energy, and are generally not involved in eco-centric activities. Logistical operations burn more fuel than other operation in order to transport goods from one point to another. For example, it is estimated that logistics movement produces 20% of all greenhouse gas emissions, consuming 35 billion gallons of diesel per year (Blanco and Cotttill, 2013). It is not surprising therefore, that businesses, especially in manufacturing, have come under global pressure to adopt Carbon Efficient Practices (CEPs) to reduce emission (Stock, 2002, Fleischmann et al., 2003, 2004, Sarkis et al., 2010; Chaabane et al., 2012; Liljestrand et al. 2015).

Extent literature reports a number of CEPs that includes closed loop supply chain, extended product life cycle such as product redesign, production planning control for remanufacturing, inventory management, product recovery, reverse logistics (RL) and carbon emission reduction (Chaabane et al., 2012; Liljestrand et al. 2015). In the developed and/or industrialized countries, stringent CEPs regulations and their enforcement mechanisms coupled with consumers' awareness drives business operations to implement CEPs such as Waste Electrical and Electronic Equipment (WEEE) and Extended Producer Responsibility (EPR) designed to enforce the collection, treatment, recycling and/or safe disposal after the End-of-Life (EoL) of products, amongst other similar regulations (Rogers and Tibben-Lembke, 2001; Ravi and Shankar, 2005; Wang et al., 2015).

The need to comply with CEPs regulations necessitates manufacturing firms re-design their products to overcome barriers to CEPs through means such as ease of disassembly of returned products for value extraction, recycling, reuse and/or remanufacturing. However, such re-design innovations require significant initial capital investment - for resources, infrastructure, training and setup – which constitutes a major barrier to firms embarking on such redesign initiatives. Firms invest scarce resources in redesign initiatives (or any initiatives) only when they are compelled to by clear insights on the real benefits of such investments. Predominant firms' barriers to new innovative practices such as suggested redesign are financial support, infrastructure and the technological systems necessary to provide capability to achieve desired objectives, in addition to government support (Rogers and Tibben-Lembke, 2001; Ravi and Shankar, 2005; Lau and Wang, 2009; Zhu and Geng, 2013).

Extant studies indicate that while the initial cost for CEPs may be significant, business operations and logistics are financially successful to a firm's long-term business operations (Stock, 2002, Fleischmann et al., 2003, 2004, Sarkis et al., 2010). Additionally, studies have empirically demonstrated that CEPs have a direct impact on firms' economic performance and their product redesign capability (Chan and Chan 2008; Lai et al., 2013). However, most of these studies associate or view the benefits from CEPs largely as by-products of external pressures to comply with environmental regulations, peer pressure, green trade barriers, amongst others (Stock, 2002, Fleischmann et al., 2003, 2004, Sarkis et al., 2010; Abdulrahman et al., 2015). These studies failed to examine how firms could be self-motivated toward CEPs implementation due to its strong attractiveness that outweighs its inherent barriers. The role of barriers can be viewed as a resistance to change and progress was well dealt with using Newton's 2nd Law of Motion. This has paramount importance in the case of developing economies such as China where, despite being the "global manufacturing factory," China lacked stringent and enforceable environmental laws allowing for increases in the intensity of these barriers. (Amighini, 2012; PricewaterhouseCoopers, 2011).

This study posits that a greater motivation for CEPs lies in firms' realization of the significant economic and overall sustainability benefits of such practices. We argue that the enhanced sustainability derivable from CEPs in terms of waste elimination and the cost savings gained through the reduced need for virgin raw materials required, in terms of value/asset recovery practices of CEPs represents the true attraction for their implementation and re-design; as opposed to regulations and their enforcements (Rogers and Tibben- Lembke, 2001; Stock 2002; Lai et al. 2013; Wang et al., 2015). Again this attraction corresponds to the acceleration observations of Newton's 2nd Law of Motion. This is evidenced in the fact that despite the existence of similar environmental regulations in developed economies, in the case of China there is a lack of corresponding stringent enforcement of regulations by government (Zhang, et al., 2011; Lai and Wong, 2012; Lai, et al., 2013; Abdulrahman et al., 2014) and insufficient levels of customers' green awareness (Smyth, et al., 2008; Tantawi et al., 2009; Tan and Lau, 2010; Ye et al., 2013). We therefore, posit that drivers of CEPs in developing economies, such as China, are entirely different from those in developed economies' context for business operations and logistics. It is therefore imperative to examine the situation from the perspective of these emerging economies.

This study uses the theoretical lens of Newton's Second Law of Motion and Contextual Interaction Theory (CIT) to propose a model that investigates the effects of drivers and barriers to CEPs in the Chinese context. The impact of CEPs drivers and barriers on product redesign activities and the performance of firms are also studied. From the perspective of Newton's 2nd Law of Motion, the force on an object is equal to the product of its mass and acceleration (mathematically, F = ma). That is, the acceleration of an object is directly proportional to the force acting on it and is inversely proportional to its mass. The mathematical relationships are sound for managerial context as per the variables captured with respect to force, mass and acceleration. Irreversibility of the three variables used in Newton's Second Law of Motion for managerial context corresponds well to the mathematical representation. Basically, this implies the more mass an object has the more the required force to initiate movement and accelerate it in the direction of the force. In the context of this study, we attribute the force behind CEPs implementation by firms to the attractiveness of these practices in terms of benefits from redesign and performance. The mass of object is considered as the barriers faced in the decision making process on whether to implement CEPs while acceleration can be viewed from the perspective of the increased improvement in product redesign capabilities leading to better performance. This contextualisation is in line with CIT, which states that in order to undertake interventions, there must be interactions amongst key factors that enable a consensus in decision-making (Bressers, 2007). We assert that the attractiveness of carbon efficient drivers overweighs the associated barriers to motivate management to implement CEPs that would eventually lead firms to improve their redesign capabilities and performance.

The major contribution of this study is the identification and modelling of the context under which the investigated Chinese manufacturing firms are likely to accept and implement CEPs based on Newton's 2nd Law of Motion and Contextual Interaction Theory (CIT). To our knowledge, this is the first study to propose and validate a conceptual model with contextual drivers and barriers on product redesign capabilities and economic performance of the Chinese manufacturing sector using Newton's 2nd Law of Motion and Contextual Interaction Theory. While past studies have examined green practices through the lens of developed economies (Stock, 2002, Fleischmann et al., 2003, 2004, Sarkis et al., 2010; Lai and Wong, 2012; Lai, et al., 2013), this study identified specific carbon efficient factors in the context of Chinese manufacturing firms and develops insights as to how they interact with each other to influence CEPs acceptance and economic performance of Chinese firms.

The remainder of the paper is structured as follows: We begin the next section with the review of related extant literature on CEPs implementation drivers, barriers and performance outcomes. The findings of the literature review are then integrated into our conceptual model and hypotheses development. The following section outlines the methodology and sample characteristics of the study, whereas the subsequent sections present the data analysis and results of the study that is followed by the discussion section. We close with our concluding remarks wherein we provide the limitations of this study.

2. Literature review

2.1 Drivers of CEPs

Carbon efficient studies have largely focused on issues pertaining to green and environmentally conscious logistics practices (Autry, 2005; Lambert et al., 2011). The environmental driver remains an important issue and is even mandatory in some European countries where standards such as the Waste Electrical and Electronic Equipment (WEEE) Directive and Extended Producer Responsibility (EPR) are strictly enforced. These standards mandate that Original Equipment Manufacturers (OEMs) of products undertake the collection, treatment, recycling and/or safe disposal after End-of-Life (EoL) of their products (Zhang et al, 2011; Lai and Wong, 2012).

However, studies suggest that apart from environmental concerns there are other important drivers. For example, companies protect their brands and reputation by recalling defective and/or accepting unwanted products from consumers (Witt, 2008; Souiden et al., 2009). The offering of 'fresh' stock that commands higher prices, and the 'take-back' of unsold or slow selling stock to avoid or reduce markdowns on older products have also been reported (Jayaraman and Luo, 2007). The most immediate reward to companies that have established efficient carbon efficient practices is the take-back and recovery of materials (assets), which were found to be highly profitable (Fleischmann et al., 2003, 2004; Sarkis et al., 2010). Asset recovery is "the classification and disposition of surplus, obsolete, scrap, waste and excess material products, and other assets, in a way that maximizes returns to the owner, while minimizing costs and liabilities associated with their dispositions" (Rogers and Tibben-Lembke, 2001). In this study, 'assets' refers to any physical substances that are capable of being refurbished and remanufactured to return them to a state of full functionality. Similarly, assets also refers to physical substances that are recovered for reuse as raw material such as precious metals, scrap metals, plastics and other materials that are recyclable. Table 1 provides a summary of the items used based on a literature review.

Insert Table 1 about here

The most critical drivers of CEPs implementation based on a literature review that was included in this study were: asset recovery, brand protection, reputation protection and profit margin protection. The study avoided the inclusion of the drivers of environmental concern and legislation because, China, being a developing country is only now awakening to the environmental and/or green movement (Tantawi et al., 2009; Tan and Lau, 2010). Specifically, literature suggests that despite China having 16 of the world's 20 most seriously polluted cities, Chinese consumers are not yet sensitive enough to environmental issues (Smyth, et al., 2008; Tantawi et al., 2009; Tan and Lau, 2010; Ye, et al., 2013). In fact, even in the more developed parts of China such as Hong Kong, people are just at the stage of green awakening. Regulation is the strongest source of external influence on a firms' RL implementation plan (Daugherty et al., 2001; Lai and Wong, 2012; Ye, et al., 2013). However, while developed nations use legislation to make it mandatory for manufacturers to undertake the responsibility for the collection, treatment, and recycling of their end of life (EoL) products, China is reported to deliberately avoid the enforcement of such strict laws for the fear that it might negatively impact the survival of Chinese firms, especially small and medium enterprises (SMEs) (Lau and Wang, 2009).

Similarly, another driver of CEPs "product recalls" was also excluded from the focus of this study as product recalls are rarely undertaken on a willing basis in domestic markets of China, although certainly this is not to imply that no recalls related issues are pertinent within the Chinese domestic markets. For example, while not many domestic recalls are recorded within China, Chinese goods accounted for 60% of all product recalls in the U.S. in 2007; with products from China being recalled twice as often as products from anywhere else (Lipton and Barboza, 2007; Farah, 2008; Berman and Swani, 2010). Most interesting is the fact that most of these recalls were noted as "due to the deliberate replacement of original ingredients with fake or substandard ingredients by Chinese manufactures in an effort to lower their costs" (Berman and Swani, 2010). Even more interesting is the fact that this type of unethical behavior was actually perpetrated against US customers who the Chinese firms involved had already established long-term relationships with (Berman and Swani, 2010). These, coupled with the absence of a strong consumer product safety agency in China and the general reluctance of the government to clamp down on sectors that it considers as the engine of social stability (due to its employment capacity), suggests that Chinese firms have little or no incentive to willingly recall products, for whatever reasons, in their domestic markets. These facts led us to also exclude drivers such as liberal return policy and customer demand as key drivers that are reported in the developed world.

2.2 Barriers of CEPs

The study adopts four categories of CEPs implementation barriers and they are management related, financial related; policy related and infrastructure/technological systems related based on the recent study by Abdulrahman et al., (2014). A summary of implementation barriers based reverse logistics is presented in Table 1.

Management barriers include: poor technical knowledge, a lack of commitment by top management and a lack of trained personnel (Ravi and Shankar, 2005; Lau and Wang, 2009). Company policies and competitive issues are also cited as management barriers (Ravi and Shankar, 2005; PricewaterhouseCoopers, 2008; Lambert et al., 2011). In addition, having an expert who can adopt a systems viewpoint throughout the supply chain to champion carbon efficient implementation is critical to success (Rigot-Muller et al., 2013).

The second category of barriers that impede CEPs is financial capital. Financial barriers to CEPs come in the form of high initial setup costs and operating costs of infrastructure and reconfigurable systems (Rogers and Tibben-Lembke, 2001; Zhu and Geng, 2013). In general, financial barriers are mostly centered on setting up collection, transportation, storage and related support activities such as training and monitoring mechanisms (Rogers and Tibben-Lembke, 2001; Zhou et al., 2007; Lau and Wang 2009). These resources increase the total cost of production (Ravi and Shankar, 2005; Lau and Wang, 2009; Zhao et al., 2013).

The third category of barriers is policy barriers. Policy barriers include restrictive company policies that lack insight into CEPs and their potential capability, and a lack of waste management practices (Rogers and Tibben-Lembke, 2001; Zhou et al., 2007; Ravi and Shankar, 2005; Zhang et al., 2011). Various studies on China have also pointed to a lack of government policy or enforceable laws on take-back of end-of-life/end-of-use products as major barriers to CEPs implementation (Zhou et al., 2007; Chung and Zhang, 2011; Lau and Wang, 2009; Li, and Colombier, 2009).

The final broad category of barriers is the lack of CEPs infrastructure and technological systems. The absence of good infrastructure and technological systems in most manufacturing firms has been well documented in the literature (Tibben-Lembke, 1999, 2001; Lau and Wang, 2009; Rahman and Wu, 2011). Specifically, Lau and Wang (2009) reported the dearth of systems, infrastructure and technology in China where "primitive tools" and a "mainly manual" sorting/recycling process is still being practiced. Zhou et al., (2007) also noted the lack of cost-effective recycling technologies and very little collaboration/coordination with third party logistics (3PL) providers in China. The lack of infrastructure and technological systems will certainly result in inadequate carbon efficient capabilities.

To summarize, we selected management, finance, policy and infrastructure related CEPs barriers (see Table 1). These barriers are likely to adversely affect the CEPs implementation in China.

2.3 Effects on product redesign capabilities

A majority of products that are returned by customers are resold "as is", remanufactured/refurbished, recycled, sent to landfills, or repackaged and sold as new. Other options include: being sent to central processing facilities, donations, sold to brokers, or sold at outlet stores (Rogers and Tibben-Lembke, 2001). In the context of developed countries, proactive companies have reported starting product development programs that encompass design for environmental initiatives, for recovery and disassembly to understand the interactions among key components and modules (de Brito et al., 2005). In the context of the Asia Pacific region, it has been emphasized that companies frequently review its return policies in order to cope up with changes in the dynamic economic environment including shortening of product life cycles in sectors such as computers and electronics products (Tan and Kumar, 2002). Yet, prior research has not addressed how proactive firms can use the opportunity available from product returns to learn more about the nature of defects in the products that were returned before warranty. This in turn can be used to prompt redesign of such products for existing markets and for new markets (See Table 1 for items product redesign).

2.4 Performance impact of CEPs

Prior literature has reported that companies consider both tangible and intangible performance outcomes stemming from CEPs implementation. Companies were able to meet their environmental responsibilities as well as attract customers and employees who were environmentally conscious (Rahman and Subramanian, 2012; Lai and Wong, 2012). These companies also witnessed increased customer satisfaction, loyalty and repeat purchases as a result of their rapid and effective service recovery actions in response to product returns and recalls (Autry, 2005; Souiden and Pons, 2009). These performance outcomes have resulted in significantly improved financial outcomes and increased profit margins for these companies (Stock, 2006; Jack et al., 2010). A summary of performance studies items used based on the Western context is reported in Table 1.

We selected the tangible outcomes of improved financial returns and increased profit margins for the purpose of this study. We avoided the intangible performance outcomes of meeting environmental and social requirements based on studies that suggest a lack of environmental concerns and a lack of Western-style strict and enforceable laws on take-back of EoL products in China (Tantawi et al., 2009; Lau and Wang, 2009; Tan and Lau, 2010).

3. Conceptual model and hypotheses development

3.1 Newton's 2nd law of motion:

Newton's 2nd law of motion explains how mass, force, and acceleration are related to each other. The acceleration of an object is directly proportional to the force acting on it and is inversely proportional to its mass. In other words, force on an object is equal to the product of its mass and acceleration (mathematically, $F = ma$). The law demonstrates that the more mass an object has the more the required force to initiate and accelerate it in the direction of the force. Applying this theory to CEPs, the rate of attractiveness of carbon efficient drivers are treated as equivalent to acceleration and it is directly related to the improvement in product redesign capabilities and performance termed as the Force (F) which ultimately satisfies stakeholders of the company. Total carbon efficient barriers are referred to as mass and hence CEPs performance will be substantially high if the overall acceleration is greater than the total resistance by the mass. Effectively, we applied Newton's 2nd Law of Motion to demonstrate that the influence of drivers of CEPs (i.e. force) is expected to be higher than the effect of barriers (object mass) to have significant positive influence on firms' innovative redesign activities that would eventually lead to higher economic performance. In other words, when incentives, considered as attractiveness in this study, outweigh the barriers (mass of the object), the resultant marginal force leads to redesign adoption (acceleration). However, the CEPs and drivers vary with respect to context depending on the characteristics of the industry and country where it takes place, hence the need for CIT to understand the perspective of Chinese manufacturing firms.

3.2 Contextual interaction theory

The transformation of a policy into adaptable programs has long been recognized by researchers and practitioners as a complex process filled with implementation challenges related to training and capacity building (Bressers, 2007). This complexity was the impetus to the formulation of Contextual Interaction Theory (CIT), a theoretical framework that states in order to undertake interventions; firms would work towards consensus building in decision-making and program implementation.

In its original form, CIT posits that the motivation of the policy maker, resource needs, and level of collaboration are key variables influencing policy and program implementation. In other words, there is an interaction between the key variables that drive the program implementation (Bressers, 2007). According to Bressers, (2007), while multiple issues are at stake in a program implementation, in many cases, 'for each issue' there will be two sided arguments: one side opposing (contextual barrier) while the other side favoring the choice (contextual driver). Figure 1 shows the process of CEPs performance with carbon efficient drivers and barriers that influence product redesign capabilities as the two-sided factors. Of course in a more complex scenario there may be many more for and against arguments. Figure 1 therefore is a simple model involving drivers and barriers (opposing contextual arguments) that influence product redesign and CEPs performance.

In our study CIT enables the understanding of the underlying contextual factors that influence CEPs implementation program within a country's specific social, economic and political context. It explains why, despite the well-known environmental and other carbon efficient policies and guidelines in the West, and their associated business benefits, the same are not being implemented or at least pursued with equal zeal in China. Context specific aspects enable us to choose suitable carbon efficient drivers and barriers for Chinese manufacturing sector as mentioned earlier in the literature review section. For example, while leading firms in the industrialized nations of the West such as Xerox, Volvo, IBM, Caterpillar and Motorola all fully embraced CEPs such as product take-back, asset recovery and reuse of their end of life products with resultant economic benefits for redesign of such returned products (Stock, 2002, Fleischmann et al., 2003, 2004, Sarkis et al., 2010), Chinese firms are still lacking in insights between RL and firms' economic performance. This coupled with a lack of government enforceable laws and regulations has resulted in a lack of required firms' management commitment and budgetary allocation for CEPs, amongst others (see Table 1: Survey items).

3.3 Conceptual model

Based on Newton's 2nd law of motion and Contextual Interaction Theory we related CEPs drivers and barriers with product redesign capabilities and performance as shown in Figure 1. The detailed discussion about the relationship and the hypothesis development are discussed below.

Insert Figure 1 about here

3.4. Carbon efficient drivers and product redesign capabilities

Companies are increasingly driven to implement carbon efficient practices as they continue to realize that it enhances their sustainability efforts through practices such as waste elimination, cost savings through reduced resort to landfilling and the extraction of value through the reuse/recycle mechanisms. A returned/recalled and recovered product can be utilized to provide a number of benefits such as overhauling and reselling products that are returned in secondary markets (Rogers and Tibben- Lembke, 2001; Stock 2002; Lai et al. 2013) to improve or protect profit margins and extracting and using parts/components (through the assets recovery process) as raw materials for subsequent production (Chan and Chan 2008; Lai et al., 2013; Tan et al., 2003).

Specifically, companies such as BMW, General Motors, HP, and Volvo have significantly benefited from take-back and asset recovery (Stock 2002; Lai et al. 2013). BMW for example, has a strategic objective to design a "totally reclaimable" automobile, which is formidable considering the number of stock keeping units (SKU) that comprise a car (Lai et al. 2013). These firms have used insights gained through carbon efficient practices implementation to develop product recoverability mechanisms through redesign (Mathieux et al., 2008; Jayal et al., 2010). A number of empirical studies have demonstrated that asset recovery directly affects product redesign and firm performance (Chan and Chan 2008; Lai et al., 2013). The study by Chan and Chan (2008) found that Hong Kong mobile phone firms witnessed positive strategic impact and good corporate citizenship through recapturing value and assets recovery from EoL products. Similarly, Lai et al. (2013) empirically found positive financial and social performance outcomes in the Chinese firms with reverse logistics implementation.

From the above discussion it is quite obvious that previous studies well reported the relationship between carbon efficient drivers and various end benefits. Interestingly, previous studies didn't document well the attractiveness of carbon efficient practices' drivers to develop the firm's redesign capabilities as well as its relationship with performance. Similarly, practical gains of carbon efficient practices reported by the automotive companies such as BMW, General Motors, HP, Volvo and others in terms of innovation/redesign and economic performance suggests these firms' carbon efficient activities significantly impact their redesign capabilities (Stock 2002; Chan and Chan 2008; Lai et al. 2013). For such firms, it is also obvious that the attractiveness of carbon efficient drivers is significantly higher than the barriers encountered to successfully implement carbon efficient practices (Reddy, 2013). As per Newton's 2nd law, the attractiveness of carbon efficient drivers – due to its enabling take-back and asset recovery of EoL products - highly influences product redesign capabilities. Similarly, as per CIT attractiveness of carbon efficient drivers should be significantly more positive than barriers to successfully develop redesign capabilities. This also signifies the needed resources and the decision making to implement carbon efficient practices should be positive in the direction of implementation (Bressers, 2007).

This leads us to hypothesize that:

H1: Attractiveness of carbon efficient drivers positively influences a *firm's to develop its product* redesign capabilities.

3.5 Barriers of CEPs and product redesign capabilities

A number of key supporting factors are required for a successful product redesign and CEPs implementation program. Critical amongst these required success factors are top management support for the project, financial support, policy and regulation to guide the activities and working of the project and the availability of adequate infrastructure and technological systems needed to provide capacity and capability to achieve the desired objectives of the product redesign. Below we examine and develop hypotheses linking key CEPs implementation barriers to product redesign.

3.5.1 Management barriers

An empirical study by Ravi and Shankar, (2005), found that barriers such as lack of technological systems, lack of training, resistance to change and indifferent policies all influence reverse logistics practice implementation, and that these barriers strongly depend on the lack of top management commitment because of its high and strong driving power. Similarly, studies found a lack of management support in the forms of reluctance to devote managerial and financial resources in green practices in the Chinese manufacturing industries (Lau and Wang, 2009; Abdulrahman et al., 2014). Essentially, lack of or low top management commitment invariably inhibits the identification and efficient integration of returns, recall, reuse and take-back of end-of-life products, and the exploration of economically viable alternatives for disposal. Furthermore, low top management commitment suggests that such firms failed to recognize the opportunity to employ their resources or technologies to generate new revenues by creating saleable products from scraps and recycled materials. Similarly, firms suffering from management barriers are also likely to miss the opportunity to convert their hazardous waste to useful products, and thus avoid costly disposal charges. The lack of top management commitment to CEPs program increases the barrier (i.e., increased object mass as per Newton's 2nd law) that can only be overcome by greater drivers (force: attractiveness or incentives) to make the CEPs program successful. Extant literature cited above reported management barrier with respect to emerging economies that are short term oriented and seek immediate gains. This is specifically a contextual barrier with respect to an emerging economy context of which China is leading member.

3.5.2 Finance barriers

Previous studies have shown that the high setup, operating and infrastructure cost prohibits widespread implementation of green practices (Rogers and Tibben-Lembke, 2001; Lau and Wang, 2009; Zhu and Geng, 2013; Abdulrahman et al., 2014). The studies by Lau and Wang (2009) and Zhu and Geng (2013) specifically note that Chinese manufacturers are exceptionally cost conscious and lack the incentive to invest in green practices. Both studies inferred that Chinese manufacturers fear that pursuing green practices will come at a disadvantage of lower costs that made China a preferred global manufacturing base. However, the result of inadequate investments in key infrastructure, manpower and monitoring mechanisms, prevents firms to efficiently recall, take-back or offer liberal return policies. The attempt to use returns/recall to improve customer service without appropriate capabilities will result in costs that would exceed any realizable benefits (Jack et al., 2010). Basically, inadequate investments in key infrastructure and systems prevent returned items to be properly handled and processed for the extraction of economic benefit. Finance barrier is critical in the emerging economies context where firms are short sighted and competing based on cost. This is a specific contextual factor that gains substantial weightage and acts as a major impediment to CEPs program implementation.

3.5.3 Policy and regulations barriers

The lack of clear enforceable laws and regulations has been identified as a major barrier to CEPs implementation in both developed and developing economies (Witt, 2008; Lau and Wang, 2009; Chung and Zhang, 2011; Abdulrahman et al., 2014). According to Witt (2008), an overwhelming majority of industry stakeholders in the US (79%) believe that recall legislation is necessary to guide the industry. Similarly, a lack of government enforceable laws and regulations have been reported to constitute severe disincentives or demotivation to invest in green practices implementation in China, as no one is willing to act alone (Lau and Wang, 2009). Also, Chung and Zhang (2011), stated that China's laws and legislation on WEEE cannot be used to control the environmental impact of WEEE effectively due to lack of specific control details and enforcement. The resultant impact of a lack of effective policy and regulation is a lack of realization of the economic and strategic performance benefits that can occur via carbon practices implementation. The policy and regulation barrier is one among the contextual factors in the emerging economies context that resists the CEPs implementation and necessitates additional support from policy makers. At the moment this barrier overlooks companies' adherence to environmental regulations.

3.5.4 Infrastructure barriers

The presence of good infrastructure and technological systems provide companies with the much needed capability and capacity to redesign their products. In their study, Stock et al. (2002) suggests that the presence of a good returns-handling system can be a source of significant cost savings and even function as a profit center. Dibenedetto (2007) found that with the presence of infrastructure systems, returns and recalls are easier to handle. Similarly, Jack et al., (2010) opined that without adequate capabilities (lack of infrastructure and technological systems); attempts to implement RL practices will result in a financial burden, with the costs exceeding the benefits.

Collectively, the barriers mentioned above could prevent efficient product return, take-back and/or recovery of products and the identification of key issues and insights that are needed for effective evaluation and redesign of products. Furthermore, previous study findings discussed above underscores the underpinnings of CIT theory employed and the influence of barriers as collective resistors to effective implementation of CEPs. Indirectly, above studies connotes the negative relationship between barriers and attractiveness to carbon efficient drivers as well with product redesign capabilities. We therefore, hypothesize that:

H2: Carbon efficient barriers are negatively associated with product redesign capabilities and retract firms from developing product redesign capabilities.

Companies with good carbon efficient capabilities are able to enhance their profit margins by offering markdowns on their older products and supplying new or "fresh" products that command premium prices on the market (Jayaraman and Luo, 2007). A survey study by Autry (2005) shows positive performance outcomes stemming from customer retention, thereby protecting sales and profit margins in automotive firms. Studies have shown that profits margins are protected or even improved by businesses that target different buyers (market segments) with returned/remanufactured/refurbished products (Lai et al., 2013). Overall, to implement CEPs as per Newton's 2nd Law of Motion, attractiveness to carbon efficient drivers should be positively related to product redesign capabilities in complete contrast to carbon efficient barriers that should be negatively related to product redesign capabilities. Hence we posit the following:

H3: Attractiveness to carbon efficient drivers' influence should be higher than carbon efficient barriers to develop the *firm's redesign capabilities.*

3.6 Product redesign capabilities and performance impact

A recent survey shows about half of US industry-leading stakeholders (46%) listed brand protection as the top reason that their companies want to improve their processes and technology (Witt, 2008). This is because consumer brand loyalty has a strong positive influence on purchase intentions (Souiden et al., 2009, Pan et al., 2012). A study by Autry (2005) suggests that RL allows companies opportunities to differentiate themselves and build consumer confidence in the company brand. Business reputation has been ranked second highest behind price as a factor influencing the value of a firm's product offerings (Cretu et al., 2007). Customers' perceptions of a company's reputation may be based on their first-hand experience with its product, or upon how well it conducts its service recovery performance or its social performance. In his study Autry (2005), posited that effective green practices help in protecting business reputation by giving companies the capability and opportunity to correct errors such as 'wrong shipments' quickly and satisfactorily. Studies have shown that profits margins are protected or even improved by businesses that target different buyers (market segments) with returned/remanufactured/refurbished products (Lai et al., 2013).

A critical success factor not often emphasized in literature is that all benefits and performance outcomes from green practices implementation are largely dependent on the way returned products are handled and processed by firms. In their study, Jack et al., (2010) warned that managers should realize that using returns to simply improve customer service without adequate capability for handling and processing the returns will ultimately result in a financial burden with the costs exceeding the benefits. Arguably therefore the most important implementation benefits come from the knowledge gained from past mistakes and the avoidance of such and/or similar mistakes through subsequent products redesign. Lai and Wong (2012) found that implementing green logistics management practices of take-back of products enable producers to discern customer usage pattern and identify areas of quality improvement. The above discussions reveal that product redesign capabilities can be improved through CEPs and would certainly lead to high performance. This leads to the hypothesis that:

H4: Firms' carbon efficient product redesign capabilities will positively enhance their performance.

4. Methodology

4.1 Research Sample

The targeted manufacturing companies were identified and randomly chosen from the China manufacturer directory (china-manufacturer-directory.com) with a focus on the east coast corridor industrial cities such as Ningbo, Shanghai, Guangzhou, Foshan and Shenzhen. The companies selected have had long-term international experience being suppliers of parts/components to foreign buyers and collaborators. Furthermore, these firms are experiencing pressures from their international customers and collaborators to adopt international norms and practices such green implementation or green-trade barriers (Zhu et al., 2012). Based on the above selection criteria, we selected the industrial sectors of automobile, steel/construction, electronic/computer, textile, plastics and paper based products where the implementation of CEPs is expected to be widespread (Rahman and Wu, 2011).

4.2 Scales and Measures

A self-administered questionnaire was used to gather the data with primary areas relating to CEPs drivers, barriers, product redesign capabilities, and performance outcomes. The scales were derived using extant literature on carbon efficient and green practices. Table 1 presents the scales used and their sources. All measures were on a five point Likert scale (with end points of 1 = strongly disagree, and 5 = strongly agree). Despite our scales being extracted from literature, a pilot test was carried out to evaluate and refine the survey questionnaire during a workshop for entrepreneurs and academics at a U.K. university based in China to ensure simplicity and clarity of the instrument (Podsakoff et al., 2003). The feedback obtained from the pilot study was used to develop the finalized survey instrument.

4.3 Data Collection Methods

Data collection was conducted through intermediaries who were either representatives of private entrepreneur associations or local government officials. The use of intermediaries is typical in the Chinese context and highlights the challenges faced in using representative sampling techniques in China, where a general distrust of outsiders could result in a low response rate to mail-based surveys. The intermediaries were trained on the questionnaire items to promote better understanding and to assure respondents of the confidentiality of the information they provide, while offering them a promise of a summary report of the final research findings. Details of the respondents are shown in Table 2.

To avoid the likely problem of linguistic or cultural differences in the translation of our questionnaire from English to Chinese, a back-translation method was employed (Su, & Parham, 2002). Two bilingual translators (English and Chinese) and academic colleagues who themselves are bilingual English and Chinese, as well as being experts in the subject area were involved in the back-translation process.

The questionnaires were answered mostly by middle and top managers of the selected companies. A total of 650 questionnaires were distributed and a total of 315 were returned and after surveys with missing responses were excluded, 239 valid responses were included in the final sample (36.76% response rate). Our response rate of 36.76% is far better than those from previous empirical studies in this field which typically had a response rate of around 17% (Lai and Wong, 2012).

We examined non-response bias by conducting wave analysis to assess the differences between late and early respondents following suggestions of Armstrong and Overton (1997). We additionally compared all respondents with 30 randomly selected non-respondents on ten non-demographic questions in the survey using ANOVA (Lohr, 1999; Mentzer and Flint, 1997). In both cases no significant differences were observed, indicating non-response bias was not an issue in this study. We used multiple methods to check for common-method bias, one of which is

Harman's one-factor test (Harman, 1960) by including all items in a principal components factor analysis and using the result of the un-rotated factor loadings (Podsakoff and Organ, 1986). Common-method bias exists where one factor accounts for most of the covariance (Podsakoff et al., 2003), which is not the case in this study as no one factor accounted for more than 50% of the variance. This was further followed by a partial correlation method (Podsakoff et al., 2003) in which the highest factor derived from a principal component factor analysis was added into the partial least square model as a control variable on the dependent variables. According to (Podsakoff and Organ, 1986), this resultant factor should best approximate common method variance if it is the factor in which all variables load. We did not find a significant increase in the variance in any of the dependent variables, suggesting no common method bias. Finally, correlation matrix did not show any high correlation factors; generally common method bias would result in very high correlations ($\gamma > 0.90$). Overall, these tests indicated no common-method bias in this study.

We followed Podsakoff et al. (2003) recommendations for minimizing socially desirable answers. Firstly, we ensured anonymity of both respondent and their firms and restricted the survey to only middle and top management level respondents. This step significantly enhanced reliability of the information gathered and greatly de-incentivized the need for socially desirable answers. Furthermore, most of our questionnaire items (such as a redesign product for a new market, protective margins and Carbon efficient expertise) are somewhat objective rather than subjective in nature, which further reduces the likelihood of socially desirable answers (Podsakoff et al. 2003). Finally, we checked for blind response through cross-examining respondents' publicly available annual reports (financial reports) against key survey items such as "improved financial returns" and increased profit margins. The findings from the companies' public financial reports indicate support for the responses received and thereby ruled out blind response bias as an issue in this data collected.

Insert Table 2 about here

5. Data Analysis and Results

To establish the structure of the relationship between our variables, exploratory factor analysis (EFA) based on component analysis with varimax rotation is carried out using SPSS and AMOS 20. Tables 3a and 3b summarize the results of EFA and reliability of the data and Eigen values for extracted factors. The varimax rotation method enables capturing of the greatest information based on least number of factors and improved reliability of the factor interpretations because it minimizes the number of variables with high loads. Using EFA as a basis, we excluded items such as 'legal compliance' and 'competitive reasons' under carbon efficient drivers, 're-designed products for new markets' under product redesign capabilities and 'realized spin-offs from environmentally sound choices', improved technology and process of production' and 'new technology and processes for production' under performance outcome, 'lack of shared understanding of best reverse logistics practices', 'our customers are not informed of our take-back channels when they purchase' under barriers with a factor loading smaller than 0.4 from further analysis considering it did not measure a specific construct (Hair et al., 2006). The final EFA output resulted in appropriate items loading on a single factor.

Table 3a shows composite reliability, Cronbach's Alpha and the average variance extracted (AVE) of each construct (excluded items shown on Table 3a were not used in estimating the reliability figures obtained). AVE is utilized to assess the discriminant validity, the square root of which should be larger than the correlations between constructs (Chin, 1998). The results showed that all items meet the requirement. The reliability or internal consistency was assessed through Cronbach's alpha coefficient and composite reliability. The study instrument demonstrated adequate reliability as shown by Cronbach's alpha of our data variables that range from 0.70 to 0.90 (Nunnally 1994). The results show that composite reliability values for all constructs are greater than 0.60, which indicate good internal consistency (see Table 3a).

A confirmatory factor analysis (CFA) was conducted using a maximum likelihood estimation method available in AMOS 20 to validate our constructs (Gerbing and Anderson, 1988). The results of the CFA measurement model and other important Fit indices examined such as chi-square/degree of freedom ratio (x^2/df), Comparative Fit Index (CFI), and Root Mean Square Error of Approximation (RMSEA), amongst others, are shown in Table 5. While literature popularly suggests a CFI threshold value of 0.9 (Bentler, 1990), the CFI value of the current model is 0.885, which is in line with the minimum requirement of 0.88 suggested in literature (Shah and Goldstein, 2006). Our RMSEA value of 0.077 is within the suggested range of less than 0.08 for a good model fit (Browne and Cudeck, 1993). These indices demonstrate a good fit between our measurement model and the data. Our CFA analysis verified both convergent and discriminant validity of the latent variables. Convergent validity refers to the degree to which a measure is correlated with other measures that it is theoretically predicted to correlate with. It was assessed by checking loadings to see whether the items measuring the same construct correlate highly among themselves (Anderson, 1987).

Discriminant validity describes the degree to which the operationalization does not correlate with other operationalization that it theoretically should not be correlated with. It was assessed by checking whether the items loaded more strongly on their intended construct rather than other constructs and by examining if the variance-extracted estimate is higher than the squared correlations (Anderson and Gerbing 1988). We further checked to ensure that any given item has higher loading with another construct by their cross loadings based on the recommendations of Henseler, Ringle and Sinkovics (2009). Results indicate all the items have their highest loadings on their designed constructs, providing additional support for discriminant validity. Table 4 shows descriptive statistics and correlations among constructs of our analysis.

Insert Tables 3a, 3b &4 here

5.1 Hypothesis testing results

Our conceptual model was tested by Structural Equation Modelling (SEM) using AMOS 20 software. Table 5 shows the key indices that suggest satisfactory model fit with x^2 (df) = 618.383(257, $p < 0.001$), CFI = 0.885, RMSEA = 0.077 and IFI = 0.886. Figure 2 shows the path coefficients and regression weights. We discuss the confirmation/rejection of our hypotheses as follows:

H1 examines the relationship between the attractiveness of carbon efficient drivers and product redesign capabilities of manufacturing firms. The path model result supports the hypothesized positive relationship between the two constructs, i.e., attractiveness of carbon efficient drivers positively influences firms to develop their product redesign capabilities (H1: $\beta = 0.50$, $p < 0.001$). Additionally, the measurement model of carbon efficient drivers (Figure 3a) indicates all measurement items within carbon efficient drivers are significant at a 0.001 level, while two items brand protection and reputation received the highest coefficient values. H2 evaluates the relationship between CEPs barriers and product redesign capabilities. The result did not support H2, which argued for a negative relationship between barriers of CEPs and firms' product redesign capabilities (H2: $\beta = -0.04$, $p = 0.197$). We, found, however, first order barrier constructs items loadings are significant on the second order barrier constructs (see Figures 3d and 4). It is conceivable that some of the first order constructs may have had a negative and significant relationship with product redesign capabilities construct. To understand the direct impact of each barrier on product redesign capabilities we carried out an analysis as shown in figure 4, which signifies that all the barriers except policy barrier have a negative effect. However, only financial and policy barriers are significant compared to the other two i.e. management and infrastructure. H3 evaluates the relative strengths of carbon efficient drivers' attractiveness to overcome carbon efficient barriers. The results support H3, i.e. attractiveness to carbon efficient drivers' influence was higher than carbon efficient barriers to develop firms' redesign capabilities supports hypothesis (H3: $\beta = 0.50 > \beta = -0.04$, $p = 0.197$). This is further supported by indirect impact of CEPs drivers' attractiveness and CEPs barriers on firms' performance (H3: $\beta = 0.11 > -0.01$, $p < 0.001$) (Figure 2). Finally, H4 evaluates the relationship between product redesign capabilities and firms' overall performance. The result supports the hypothesized positive relationship between the two constructs. In other words, firms' carbon efficient product redesign capabilities positively enhances its overall performance (H4: $\beta = 0.22$, $p < 0.001$). It is also interesting to note that both items, namely, 'new products for the existing market' and 'improved products for a new market' in the product redesign capabilities construct were significant with high loadings (Figure 3 b). Table 6 provides a summary of the hypothesis testing results.

Insert Table 6 here

The SEM results show that the attractiveness of carbon efficient drivers positively influences firm's to develop its product redesign capabilities while carbon efficient barriers are negatively associated with product redesign capabilities and retract firms from product redesign capabilities. Furthermore, attractiveness to carbon efficient drivers' influence should be higher than carbon efficient barriers to develop firms' redesign capabilities (See Figure 2). Theoretically acceleration or attractiveness of carbon efficient drivers should be greater than carbon efficient barriers to gain substantial product redesign capabilities or gain force as well as to implement CEPs.

5.2 Post hoc analysis

Our analysis for understanding the significance of H2 (Carbon efficient barriers are negatively associated with product redesign capabilities and retract firms from product redesign capabilities) was not supported by the SEM test. We conducted a thorough mediation analysis to re-examine the data with a view of providing robust interpretation of the linkages between our independent and dependent constructs and to tease out further insights from the results.

First, we examined the direct effect of our two exogenous constructs (CEPs drivers and CEPs barriers) separately to firms' performance before examining the mediating role of product design capabilities in both cases. Tables 7 and 8 show SEM analysis results for post hoc models 1 and 2 respectively.

Insert Tables 7 & 8 here

Model 1 results indicate the direct effect of CEPs drivers on performance was significant ($p < 0.007$). However, upon adding Product Redesign Capabilities (PRCs), the impact on performance became non-significant (Table 7). Similarly, Model 2 results also indicate the direct effect of CEPs barriers on performance was significant ($p < 0.002$). However, after adding PRCs, the impact on performance remained significant ($p<0.001$) while barriers to PRCs on performance as well as PRCs on performance are non-significant (Table 8). The resultant effect of these two post hoc models 1 and 2 results is that while PRCs has significant direct effect on performance, it is not an important mediating factor.

6. Discussion

6.1 Drivers of carbon efficiency

As indicated in figure 2, regarding direct impact of carbon efficient drivers and product redesign capabilities, the study found strong and significant support for the direct relationship between drivers and product redesign capabilities. This demonstrate that the recovery of previously discarded physical substances that are capable of being refurbished and remanufactured to return them to full functionality, or physical substances that are recoverable for reuse as raw material such as precious metals, scrap metals, plastics and other similar physical materials that are recyclable will definitely improve product redesign capabilities. That is, firms that protect their brands through activities such as recalls/returns from the customer and/or take-back of end-of-life products would enjoy long term benefits through product redesign capabilities. This demonstrates that the recovery and reuse/ recycling, refurbishing and/or remanufacture are certainly better options for manufacturers than disposal, as these carbon efficient drivers definitely improves product redesign capabilities and performance of firms. Similarly, based on the descriptive statistics (Table 4), the carbon efficient drivers have the highest mean scores of all the constructs. The two major attractive variables of carbon efficient drivers are the protection of reputation (3.820) and protection of brand (3.732). Our findings linking drivers, product redesign capabilities and performance concurs with previous studies, which stated a direct relationship between that recovery through recalls/returns and that take-back improves economic performance of firms (Stock, 2002; Liu et al., 2008; Sarkis et al., 2010).

Contextually our study indicates firms that protect their brands through green activities such as recalls/returns from customer for whatever reasons and/or take-back of end-of-life products would be able to build their product redesign capabilities that would ultimately benefit the companies in the long run. This finding is in line with literature that suggests that a liberal return policy as an integral part of customer relationship management keeps customers satisfied and loyal and enables companies to benefit from customers' lifetime value (Boyer and Hult, 2005; Witt, 2008; Souiden and Pons, 2009). In other words, manufacturers who aimed at protecting their reputation through CEPs witnessed significant impact on product redesign capabilities. This is similar to the literature that suggests that a company's reputation affects customers' loyalty, perceived quality and purchase intention (Cretuet al., 2007; Dinnie et al., 2006; Souiden et al., 2009). Our results suggest that manufacturers would be better off implementing CEPs as a positive and significant relationship exists between protecting the firms' reputation and all performance outcomes. Previous studies support this finding as well (see, Stock, 2002; Liu et al., 2008; Sarkis et al., 2010). Our study emphasises contextually firms that are able to overcome resistance if the attractiveness of carbon efficient drivers are substantially higher than obstacles that inhiit it, enabling them to build redesign capabilities resulting from the take back initiatives that by default yields them higher performance.

6.2 Barriers of carbon efficiency

Our investigation shows that more concerted efforts on the parts of manufacturers and government are needed to overcome barriers in the Chinese manufacturing sector. The general results indicate that the key management barriers to CEPs implementation in the Chinese manufacturing sector based on descriptive statistics (Table 4) are: lack of knowledge in CEPs (3.552) and lack of CEPs expertise at the management level (3.293) and lack of trained personnel (3.230). These findings are in line with previous studies (Ravi et al., 2005; Lau and Wang, 2009). A high knowledge in CEPs and presence of a carbon efficient expert at the top management level should lead to a full realization of the importance of CEPs to business operations and its potential for firms' future competiveness. Interestingly, from the response raw data, management barriers were considered to be a major issue. However analysis reveals that it is significant when management barriers are treated as a second order construct. However, when it directly interacts as shown in figure 4 it doesn't have substantial impact on product re-design capabilities.

Our results show a general lack of financial resources that include key financial measures of lack of initial capital, lack of funds for carbon efficient related practices in general, lack of funds for training and lack of funds for return monitoring systems as major financial barriers to CEPs implementation in China. Essentially, a lack of financial resources (3.310) invariably leads to a lack of capability to handle, evaluate and extract value form returns/recalls as supported in past studies (Ravi et al., 2005; Wu and Cheng, 2006; Lau and Wang, 2009; Autry, 2005; Jack et al., 2010). In particular, CEPs implementation faces a rather unique challenge in China as Chinese firms are reported as being highly cost conscious in order to remain competitive in a global environment (Zhao et al., 2013; Wu and Cheng, 2006; Lau and Wang, 2009). Foreign firms may be concerned with investing significantly in RL because of a number of factors that may include uncertainty in investment policy, restrictions on fund repatriations out of China and the general investment climate. To overcome this financial barriers that could lead to achieving meaningful performance outcomes, attractive drivers in terms of external pressures and support through stringent government policy may be required, especially for local firms.

The Chinese manufacturing sector suffered from a number of critical policy barriers that included a lack of enforceable laws and regulations on EoL products (3.536), a lack of government supportive policy (3.515), a lack of in-house green design policy and a lack of insight between CEPs, product redesign capabilities and performance. In their study, Lau and Wang (2009) found that the lack of enforceable legislations and economic incentives from the government acted as a major disincentive for Chinese manufacturers to invest and/or collaborate in CEPs implementation. In fact, Lau and Wang (2009) noted that Chinese officials were concerned that enforcing strict laws such as the WEEE, and take-back laws (that make it mandatory for OEMs to undertake the responsibility for the collection, treatment, and recycling of their EoL products) might have a negative impact on the survival of Chinese firms, which are largely SMEs (Lau and Wang, 2009).

Essentially, the developed countries' success with CEPs is a direct function of clear federal and/or state enforceable laws and regulations, and the transparent nature of their application. A clear and transparent enforceable laws and regulations encourage investment and induce competition in related carbon efficient practice R&D and implementation. On the contrary, a lack of clear policies is a disadvantage to investments; as investors would have no concrete ways of make any form of cost-benefit analysis and assessments of their potential investments for the future. China, in contrast to the West, creates a cloud of uncertainty for companies due to the vague nature of its current environmental regulatory structure and a lack of enforceable regulation on take-back of EoL products. To avoid unfavourable policy changes and/or policy reversals that could prove to be detrimental and costly to accommodate, Chinese companies have simply avoided CEPs implementation.

Our results also indicate the influence of policy barriers. Lack of internal policies on waste management, reuse or recycling through CEPs implementation or external government enforced policy of take-back of end-of-life products imply loss of profit margins that could have been associated with good CEPs implementation. Managers should realize that effective internal policy of minimizing waste, reuse, and recycling could provide significant economic and strategic benefits such as an increase in profit margins and being considered a socially responsible firm.

The findings of this study revealed a severe lack of infrastructure (3.393) in he Chinese manufacturing sector that includes a lack of systems (hardware/software) to monitor returns (3.352) were in the major number of firms investigated. This was not surprising as the absence of good carbon efficient systems in most manufacturing firms has been widely reported (Tibben-Lembke, 1999, 2001; Lau and Wang, 2009; Rahman and Wu, 2011). Lau and Wang (2009) reported a severe dearth of green infrastructure and technology in China where even a 3PL provider's WEEE recycling center uses "primitive tools with no automation in the recycling process." However, infrastructure barriers were reported to be negatively and significantly related to performance outcome. Our insight from this finding is that our sample companies are accepting returns to improve their customer service despite their lack of infrastructural capabilities for cost effective handling of returns and/or recalls. Managers should realize that using returns to improve customer service without adequate capability ultimately results in financial burden with the costs exceeding the benefits (Jack et al., 2010).

Overall our analysis reveals that barriers are not so significantly affecting development of product re-designs capabilities when they are treated as second-order constructs. However policy and financial barriers are significantly influencing the development of product re-design capabilities more than management and infrastructure barriers. Theoretically, the Chinese context needs substantial attractive drivers for rapid development of product redesign capabilities that would subsequently improve the overall firm's performance and motivates them to engage in CEPs.

6.3 Product redesign capabilities

Both improved products for new markets and new product development for existing markets that measured product redesign capabilities have relatively high average scores of 3.46 and 3.33 respectively (Table 4). This implies that Chinese manufacturers can further improve their CEPs implementation and performance by considering green practices as part of a business growth strategy, and investing sufficiently in green systems and manpower skills. Managers should realize the importance of product redesign capabilities and the take-back of products in the secondary market. This is because effective green implementation, as demonstrated in this study, will enable this effective control of a products lifecycle. It would also enable the maintenance of the all-important customer lifecycle through repeat purchases with laudable achievements (Autry, 2005; Souiden and Pons, 2009; Lai and Wong, 2012).

7. Conclusion

The objective of this paper was to examine the combined effects of CEPs drivers and barriers on product redesign capabilities and performance outcomes in the Chinese manufacturing firms. Using Newton's 2nd Law of Motion and Contextual Interaction Theory (CIT), we explain why, despite the well-known environmental and other green policies, guidelines and associated business benefits in the West, CIT is not being implemented with equal zeal in the Chinese manufacturing industry. The motivations (drivers), and the barriers variables influencing carbon efficient policy in the West are different than in Chinese contexts. Our results indicate that the key attractive carbon efficient drivers in Chinese manufacturing companies are assets recovery, brand and reputation protections and margin protection. The study established that, in the context of China, the major barriers to CEPs implementation are with respect to financial and policy aspects rather than infrastructure and management. The study revealed that CEPs implementation can enable manufacturing firms to achieve significant gains in product redesign capabilities and subsequently lead to better performance outcomes.

Limitations to this research are in terms of the selection of different manufacturing industries. It would be appropriate to replicate this research on a large-scale data of a given manufacturing industry one at a time to establish specific CEPs drivers, challenges and performance outcomes within the industry. An attempt to investigate impacts of other drivers not considered in this study such as customer demand, legislation, recalls/returns is also recommended. Our study has noted in-house infrastructure deficiencies in carbon efficient implementation are a general problem than financial issues. It would be useful to investigate 3PL providers in China and their capabilities, as most firms may likely outsource their CEPs in the future. Finally, the study sample can be categorized into two levels based on industrial sophistication (see table 2): (i) advanced companies (automotive and electronics and computers – 20.1%) and (ii) basic transformational companies (remaining including the rest- 79.9%). Due to the dominance of basic transformational companies our study didn't investigate the micro impact on each category. Hence future studies should check whether inclinations to product designs are affected by drivers and barriers in different ways in these two broad classes of companies.

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Table 1: Survey items

Factors	Elements	Source
	Drivers	
Assets Recovery	Material recapture; assets recapture; Product or equipment return repair and reuse; Recovering economic values and legal compliance	Rogers and Tibben-Lembke (2001), Stock (2002), de Brito and Dekker (2002), Fleischmann et al., 2003, 2004; Autry (2005), Jayaraman & Luo (2007), Liu, et al., (2008), Kapetanopoulous, P. et al., (2010); Sarkis et al., (2010)
Brand Protection	Protect brand loyalty; increase purchase intention	Autry (2005), Witt (2008), Dinnie et al. (2006), Souiden et al., (2009)
Reputation Protection	Image protection	Autry (2005), Cretu et al. (2007),Witt, (2008), Dinnie et al. (2006), Souiden et al., (2009)
Margin Improvement	Lower costs; increased profits from decreased resource investment; competitive reasons	Stock, (2002), (2006), Liu, et al., (2008), Fleischmann et al., (2003), (2004), Jayaraman & Luo (2007); Kapetanopoulous, P. et al., (2010)
	Reduce markdowns on older products Targeting different (market) buyers	Stock (2002), Jayaraman and Luo (2007)
	Barriers	
Management	Management inattention Lack of top management commitment	Rogers and Tibben-Lembke (2001), Ravi & Shankar (2005),
	Lack of trained personnel	Ravi & Shankar (2005),
	Lack of personnel resources; Lack of knowledge in best carbon efficient practices; Poor level of technical knowledge	Chung and Zhang (2011), Abdulrahman et al., 2014,
	Lack of expert at management level	Kumar and Putnam (2008)
Financial	Lack of initial capital; High initial cost of carbon efficient practices implementation	Zhu and Geng (2013), Lau and Wang (2009), Abdulrahman et al., 2014,
	Lack of financial resources	Wu and Cheng (2006), Ravi & Shankar (2005), Abdulrahman et al., 2014,
	Lack of funds to monitor return systems	
	Lack of funds to train personnel	
	Lack of funds for storage and handling	
Policy	Lack of government; Company supportive policy	Ravi & Shankar (2005), Abdulrahman et al., 2014,
	Lack of enforceable laws, regulations and directives on End of Life products	Zhou et al. (2007), Lau and Wang (2009), Ongondo et al. (2011), Abdulrahman et al., 2014,
	Lack of in-house green design policy; our customers are not informed of our takeback channels when they purchase.	
	Lack of insight between carbon efficient practices and performance	PricewaterhouseCoopers (2008)
Infrastructure	Lack of infrastructure for carbon efficient practices	Dibenedetto (2007), Lau and Wang (2009), Abdulrahman et al., 2014
	Lack of information/monitoring/technological systems / EDI standards / underdeveloped recycling technologies	Ravi & Shankar (2005), Rogers and Tibben-Lembke (2001), PricewaterhouseCoopers (2008)
	Lack of in-house facilities	Abdulrahman et al., 2014
	Product Redesign	
Redesign for New Market	New product design for new market from returns product handling; re-designed product for new markets	Rogers and Tibben-Lembke (2001); de Brito et al., 2005
Redesign for Existing Market	New product design for an existing market from returns product handling	de Brito et al., 2005; Tan and Kumar (2002)
	Firm Performance	
Improved Financial Returns	Improved financial returns through cost savings; Elimination of wastes; Reduced resource requirement due to returns; Realised spin-offs from environmental sound choices; Improved technology and process of production and New technology and processes for production'	Stock, et al. (2002), Stock (2006), Jayaraman & Luo (2007)
Increased Profit Margins	Maximizing total revenue; Lowering costs and increased profits	Stock et al., (2002), Jayaraman & Luo (2007), Jack et al., (2010)
Increased Return Customers	Using carbon efficient practices to increase customers' satisfaction and loyalty; Satisfying and keeping an existing customer; Minimizing customer turnover	Johnson (2002), Fleischmann et al., (2003), (2004); Kotler & Armstrong, (2004), Autry, (2005), Dinnie et al. (2006), Souiden& Pons (2009)

Table 2: Companies' Profile (n = 239)

Company characteristics	Percentage (%)
Industry	
Automotive	6.3
Paper and paper based products	13.4
Steel and Construction	24.7
Electronics and computer	13.8
Textiles	31.8
Plastics	10.0
Years Since Establishment	
< 10 years	64.9
> 20 years	35.1
Annual Sales (Recent Fiscal Year)	
< 50 million	38.9
> 50 million	61.1

Table 3a: Factor loading and descriptive statistics

First order construct	Second order construct	Variables	Factor loading	Cronbach's Alpha	Composite reliability	AVE
CEPs drivers	--	Protect margin	0.69	0.71	0.90	0.25
		Protect reputation	0.84			
		Protect brand	0.80			
		Asset recovery	0.60			
Product redesign capabilities	--	New product for existing market	0.84	0.70	0.64	0.57
		Improved product for new market	0.51			
		Realized spin-offs	0.35	Items dropped due to low loadings		
		Improved technology and process	0.47			
		New technology and process	0.42			
		New product for a new market	0.49			
		Improved product for existing market	0.47			
Performance	--	Improved financial returns	0.82	0.70	0.82	0.70
		Increased profit margins	0.79			
		Increased return customers	0.65			
CEPs barriers	Manageme nt	Management commitment	0.63	0.87	0.81	0.56
		Trained personnel	0.70			
		Knowledge in practice	0.62			
		CE expert	0.56			
		Understanding of RL significance	0.42	Items dropped due to low loadings		
		Awareness at operational level	0.41			
	Financial	Initial capital	0.84	0.90	0.86	0.78
		Financial resources	0.84			
		Funds to monitoring return system	0.77			
		Funds to train personnel	0.80			

		Funds for storage and handling	0.79			
	Policy	Govt. supportive policy	0.65	0.82	0.75	0.63
		Laws and regulations	0.71			
		In-house green design policy	0.72			
		Insights between CE &performance	0.61			
		In-house waste management policy	0.52	Items dropped due to low loadings		
	Infrastructure	CE monitoring system	0.64	0.76	0.64	0.73
		In-house CE facilities	0.64			
		CE infrastructure	0.72			

Table 3b: Eigen values for extracted and descriptive statistics

Component	Initial Eigen values			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	8.868	38.557	38.557	8.868	38.557	38.557	4.540	19.741	19.741
2	2.511	10.918	49.476	2.511	10.918	49.476	4.360	18.955	38.696
3	1.631	7.091	56.566	1.631	7.091	56.566	1.981	8.612	47.308
4	1.159	5.041	61.607	1.159	5.041	61.607	1.884	8.189	55.497
5	1.082	4.704	66.311	1.082	4.704	66.311	1.736	7.549	63.047
6	.914	3.975	70.286	.914	3.975	70.286	1.665	7.239	70.286

Table 4: Mean values, standard deviation (SD) and correlation

					RL Drivers				RL barriers																RL product		Performance		
									Management				Financial					Policy				Infrastructure							
			Mean	SD	AR	PB	PR	PM	MC	TP	KP	CE Ex	IC	FR	FMRS	FTP	FSH	GSP	LR	InHGDP	ICE&P	MS	InH CE F	CE INF	NPEM	IPNM	IRC	IFR	IPM
RL Drivers		AR	3.2	1.2	1.0																								
		PB	3.7	1.1	0.3	1.0																							
		PR	3.8	1.1	0.2	0.6	1.0																						
		PM	3.4	1.2	0.5	0.3	0.3	1.0																					
RL barriers	Management	MC	3.1	1.4	0.3	0.0	0.0	0.2	1.0																				
		TP	3.2	1.5	0.1	0.1	0.2	0.1	0.6	1.0																			
		KP	3.6	1.2	0.1	0.1	0.1	0.0	0.6	0.5	1.0																		
		CE Ex	3.3	1.3	0.2	0.0	0.0	0.2	0.6	0.6	0.5	1.0																	
	Financial	IC	3.3	1.3	0.2	0.1	0.0	0.1	0.5	0.4	0.5	0.4	1.0																
		FR	3.3	1.5	0.2	0.1	0.2	0.2	0.5	0.4	0.4	0.4	0.8	1.0															
		FMRS	3.3	1.4	0.2	0.1	0.1	0.1	0.6	0.5	0.5	0.5	0.7	0.6	1.0														
		FTP	3.3	1.3	0.2	0.1	0.1	0.1	0.5	0.5	0.5	0.4	0.7	0.6	0.6	1.0													
		FSH	3.2	1.3	0.1	-0.0	0.1	0.2	0.5	0.4	0.5	0.4	0.6	0.5	0.6	0.5	1.0												
	Policy	GSP	3.5	1.3	0.1	0.2	0.1	0.2	0.4	0.4	0.4	0.4	0.5	0.5	0.4	0.5	0.4	1.0											
		LR	3.5	1.4	0.2	0.2	0.1	0.2	0.4	0.4	0.4	0.4	0.5	0.6	0.4	0.5	0.4	0.7	1.0										
		InHGDP	3.4	1.3	0.2	0.2	0.3	0.2	0.5	0.3	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.4	1.0									
		ICE&P	3.2	1.4	0.2	0.1	0.1	0.1	0.5	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.4	0.4	0.5	1.0								
	Infrastructure	MS	3.4	1.3	0.2	0.1	-0.0	0.1	0.5	0.4	0.5	0.6	0.5	0.4	0.6	0.5	0.4	0.5	0.4	0.3	0.4	1.0							
		InH F CE	3.2	1.4	0.2	-0.1	-0.1	0.2	0.5	0.4	0.4	0.5	0.5	0.5	0.4	0.5	0.5	0.3	0.3	0.4	0.4	0.4	1.0						
		CE INF	3.4	1.3	0.2	0.1	0.1	0.1	0.7	0.5	0.6	0.6	0.5	0.6	0.6	0.6	0.4	0.5	0.5	0.5	0.5	0.6	0.5	1.0					
RL product		NPEM	3.3	1.2	0.4	0.2	0.2	0.1	0.1	0.1	0.1	-0.0	0.1	0.1	-0.1	0.1	-0.1	0.0	0.1	0.0	0.1	0.1	0.0	0.0	1.0				
		IPNM	3.5	1.2	0.2	0.2	0.2	0.2	-0.0	-0.0	0.0	0.0	0.0	-0.0	-0.1	-0.0	-0.0	0.1	0.0	0.1	-0.0	0.1	-0.0	-0.0	0.5	1.0			
Performance		IRC	2.5	1.4	0.2	0.1	0.0	0.1	0.4	0.2	0.2	0.2	0.3	0.3	0.2	0.2	0.3	0.2	0.2	0.2	0.1	0.2	0.3	0.3	0.0	-0.1	1.0		
		IFR	2.8	1.4	0.2	0.2	0.1	0.2	-0.1	-0.1	-0.2	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1	-0.0	-0.2	-0.2	-0.1	-0.2	-0.1	0.1	0.1	0.3	1.0	
		IPM	2.9	1.3	0.1	0.1	0.0	0.2	-0.2	-0.2	-0.1	-0.2	-0.2	-0.2	-0.3	-0.2	-0.2	-0.2	-0.1	-0.2	-0.3	-0.2	-0.1	-0.2	0.1	0.1	0.2	0.7	1.0

Key: AR:asset recovery; PB:Protect brand; PR: Protect reputation; PM: Protect margin; MC:Management commitment; TP:Trained personnel; KP:Knowledge in practice; CEEx: CE expert; IC: Initial capita; FR:Financial resources; FMRS: Funds to monitoring return systems; FTP:Funds to train personnel; FSH: Funds for storage and handling; GSP: Govt. supportive policy; LR: Laws and regulations; InHGDP: In-house green design policy; IRLP: Insight between CE & performance; MS: Monitoring systems; InHFCE: In-house facilities for carbon efficient practices; CEINF: Infrastructures; NPEM: New product existing market; IPNM: Improved product new market; IRC: Increase return customers; IFR: Improved financial returns; IPM: Increased profit margins.

Table 5: Fit indices of the CFA and path models

	x^2(df)	Normed x^2	CFI	RMSEA(% CI)	IFI
CFA model	618.383(257)	2.41	.885	.077	.886
Path model	659.209(261)	2.52	.883	.080	.875

Table 6: Summary of hypothesis testing results

Path	Standardized weight	Critical ratio	p-value	Note
H1: Attractiveness of carbon efficient drivers positively influences firm's to develop its product redesign capabilities	0.5	3.694	< 0.001	supported
H2: Carbon efficient barriers are negatively associated with product redesign capabilities and retracts firms from product redesign capabilities.	-0.04	-1.289	0.197	Rejected
H3: Attractiveness to carbon efficient drivers' influence should be higher than carbon efficient barriers to develop firm's redesign capabilities.	0.5 > -0.04	3.694	< 0.001	supported
H4: Firm's carbon efficient product redesign capabilities will positively enhance its performance.	0.22	2.797	<0.01	supported

Notes: Fit statistics: Chi-square=659.209 (df=261, p<0.001), CMIN/DF=2.52, CFI=0.883,

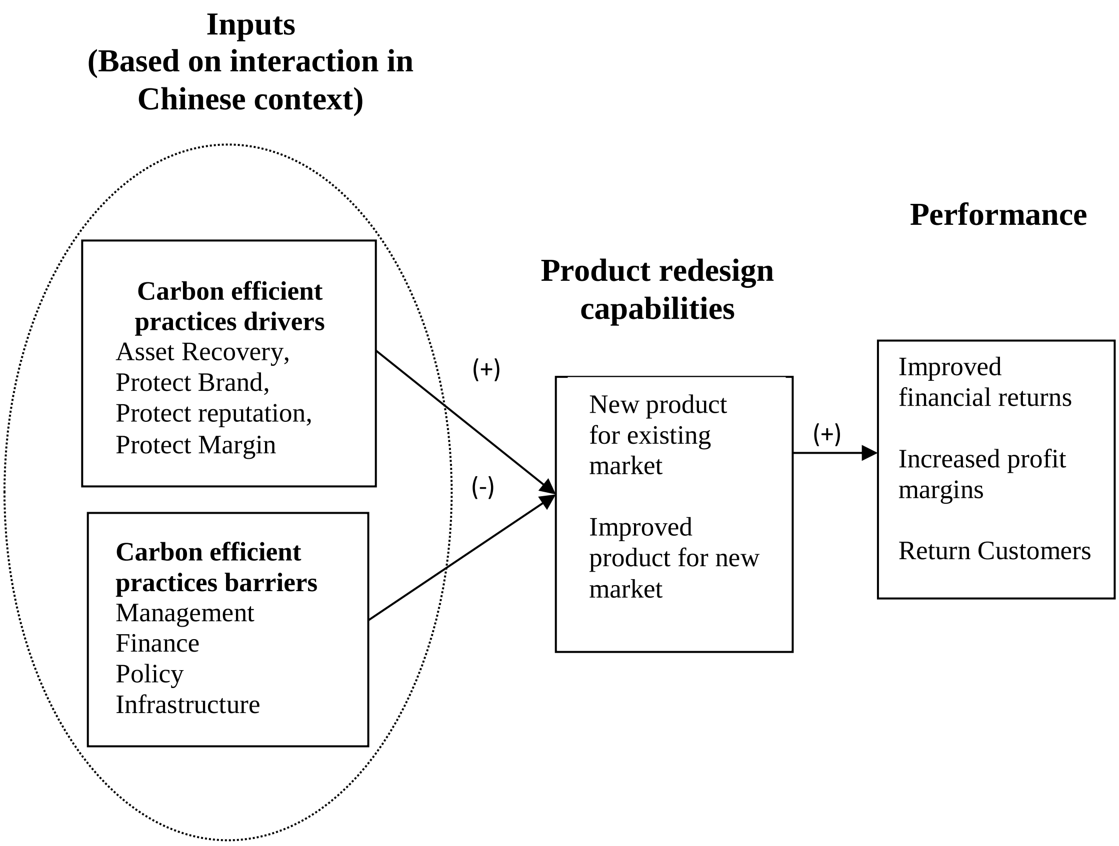

Figure 1: Carbon efficient drivers and barriers on product redesign capabilities and performance

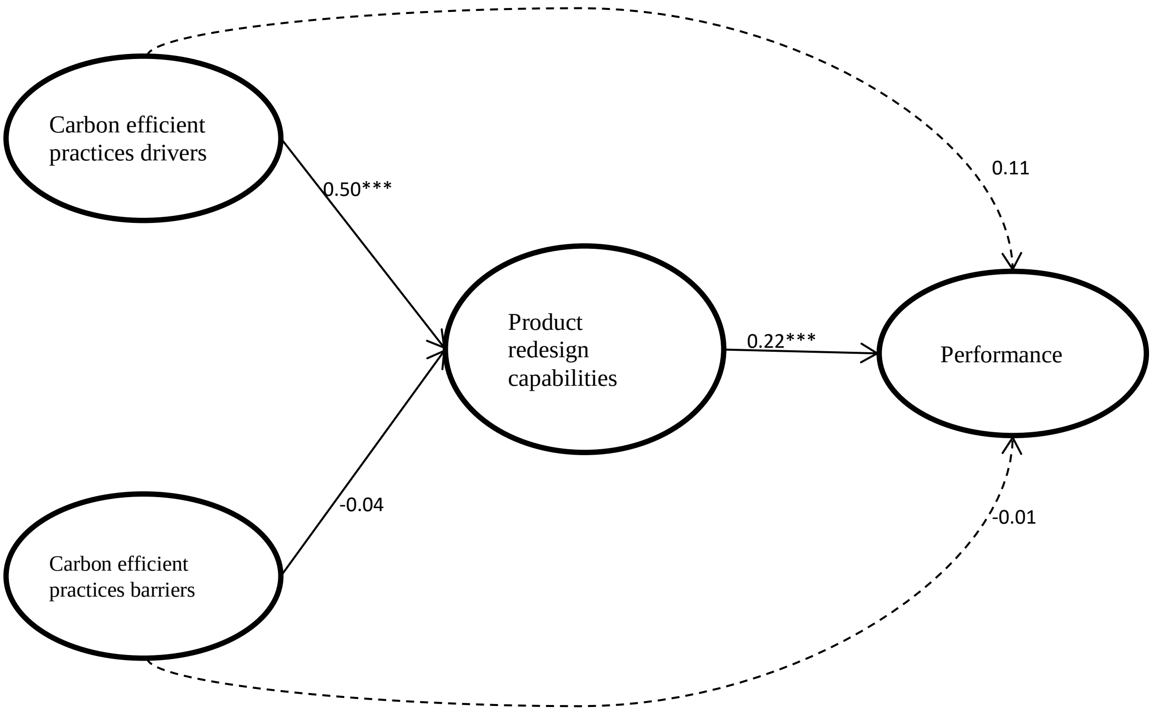

Figure 2: Structural equations modeling path model

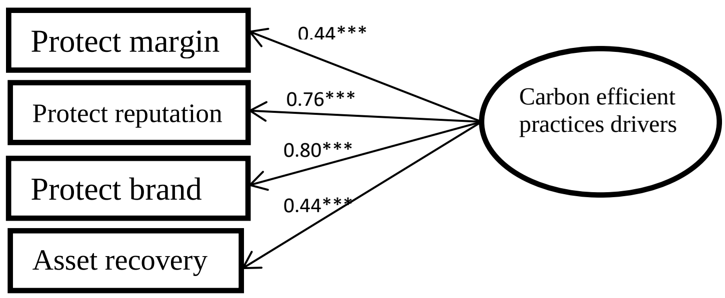

Figure 3 a: Measurement model of carbon efficient drivers

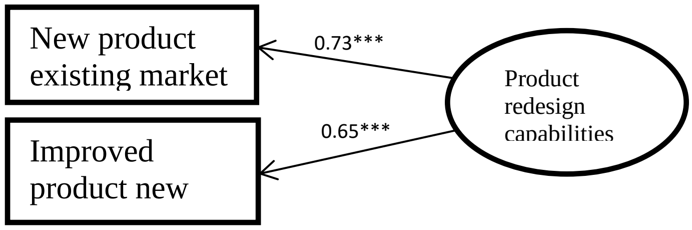

Figure 3 b: Measurement model of product redesign capabilities

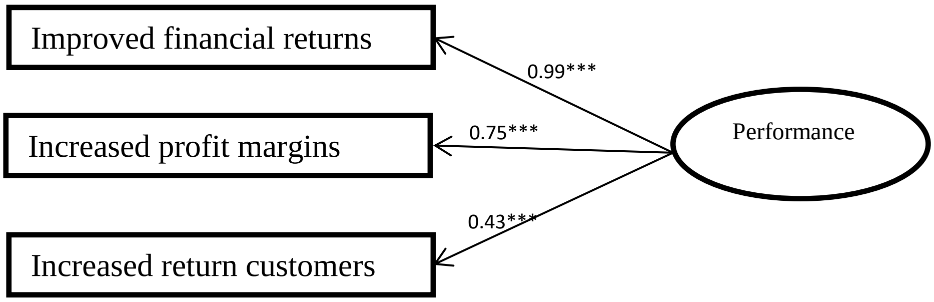

Figure 3c: Measurement model of performance outcomes

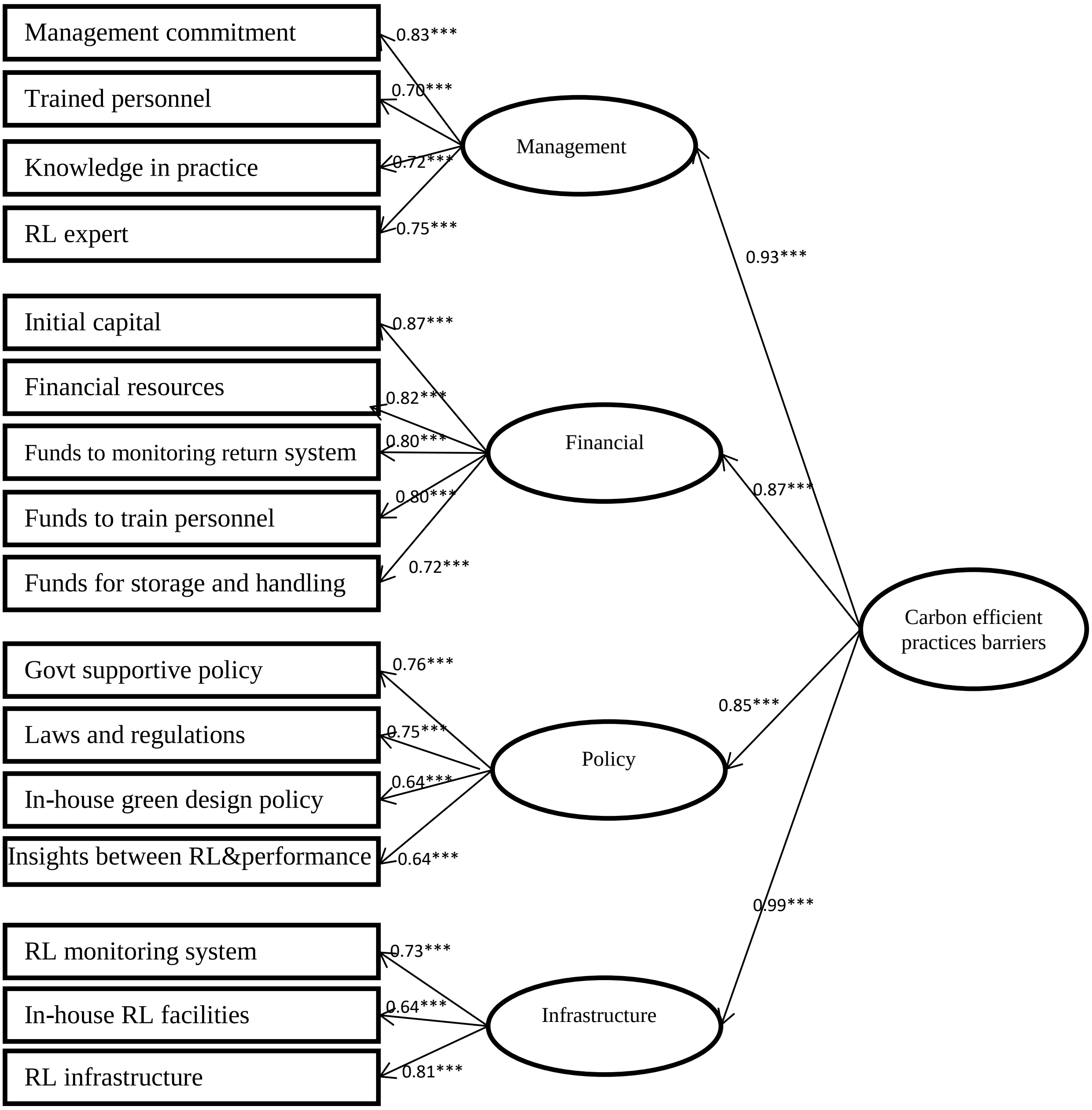

Figure 3d: Measurement model of CEPs barriers

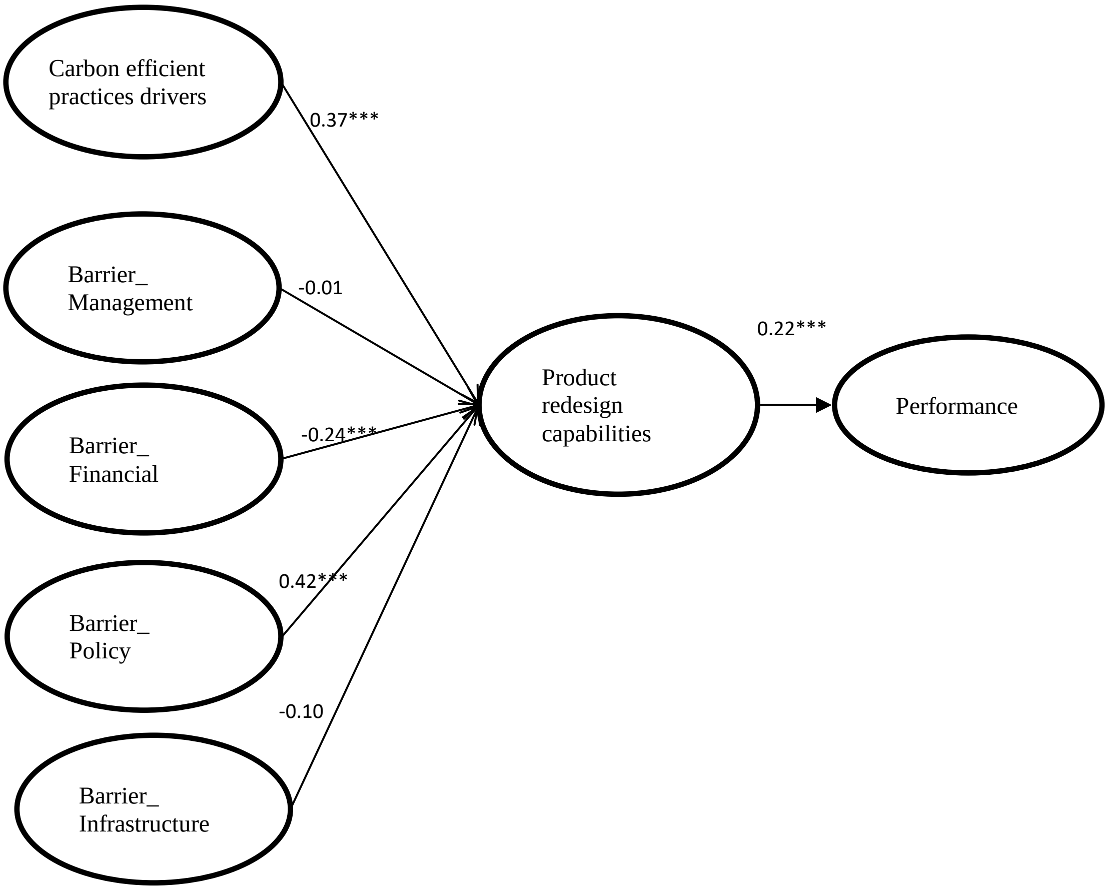

Figure 4: Direct impact of four barriers on product redesign capabilities and performance